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**TECHNICAL MEMORANDUM**  
**Remedial Investigation Findings**

**Naval Weapons Industrial Reserve Plant**  
**Bedford, Massachusetts**

Submitted to:

Martin Marietta Energy Systems, Inc.  
Oak Ridge, Tennessee  
General Order No. 89B-97383C



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## 1.0 INTRODUCTION

This Technical Memorandum presents the findings of the initial Remedial Investigation (RI) phase of study at the Naval Weapons Industrial Reserve Plant in Bedford, Massachusetts (NWIRP Bedford). It briefly examines the physical and chemical analytical data derived from soil, surface water, and the first round of groundwater sampling conducted at the site. It also presents preliminary conclusions on geologic, groundwater, and potential contamination relationships and makes recommendations regarding future study requirements.

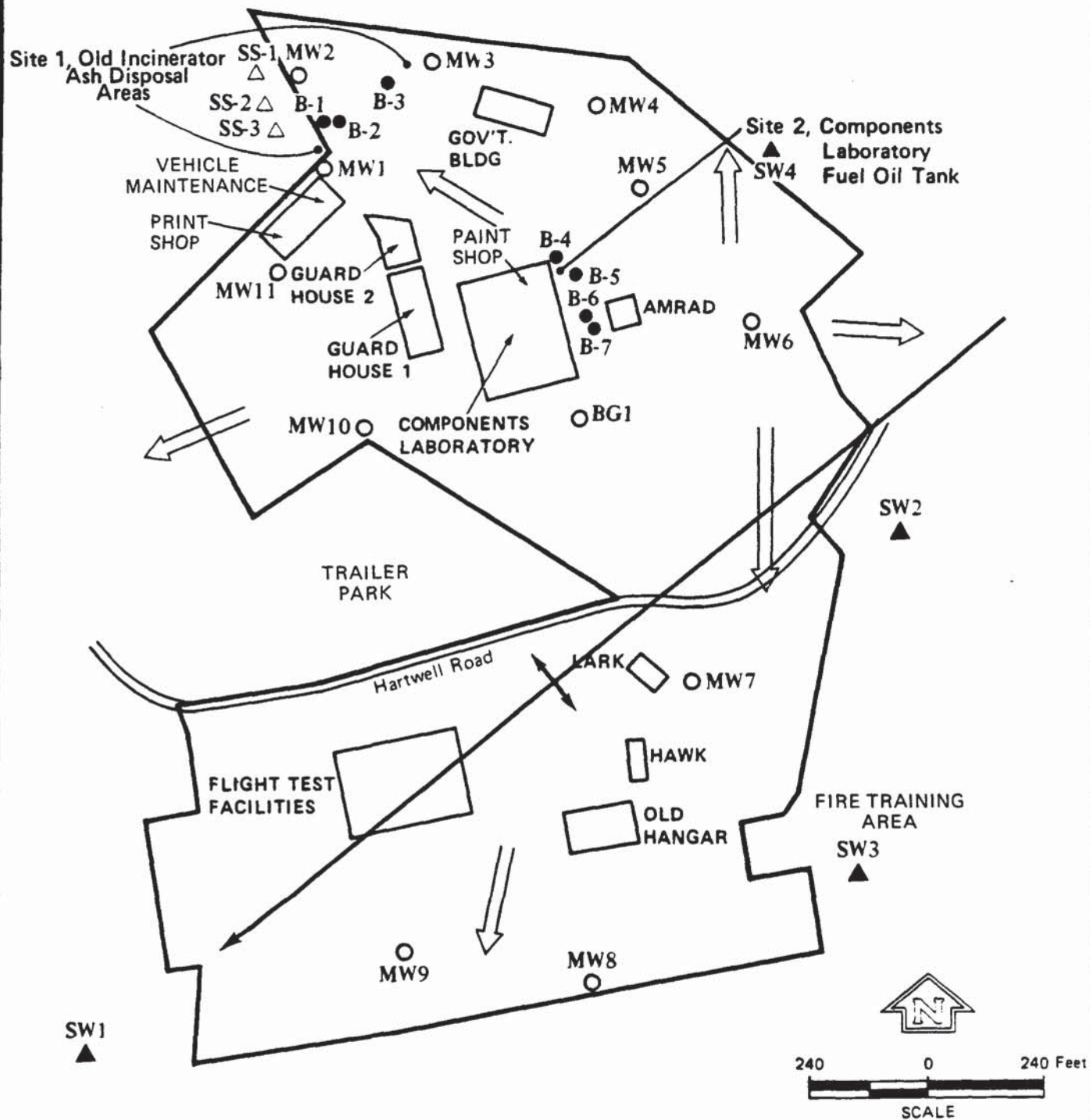
Dames & Moore conducted the initial phase of RI field investigation from March through June 1989. The purpose of the investigation was to develop a data base for the evaluation of potential contamination related to past storage and disposal practices. Attention centered specially on two sites (Figure 1): the Old Incinerator Ash Disposal Area (Site 1) and the Components Laboratory Fuel Oil Tank Area (Site 2), and in a more general sense, on the remainder of the plant.

Because of what was learned in constructing the wells and the findings of this first sampling round, it was decided to prepare a brief interim report. This was done to assess the data in light of the proposed work plan and to determine if any changes or mid-course corrections should be made.

## 2.0 SAMPLING PROGRAM

### 2.1 SOILS

Four hundred and thirteen soil samples were collected and examined during well drilling, soil boring, and hand auguring (Table 1). Twenty-five samples were selected from split spoon samples during well construction, soil borings, and shallow soil sampling. These were selected for chemical analysis on the basis of three criteria: organic vapor detections using the jar headspace test as requested by the Massachusetts DEP, analyses scheduled in the work plan, and/or observations of staining, odor, or other obvious signs of potential contamination. A total of seven soil borings were constructed, three at Site 1 and four at Site 2 and 18 samples were



**LEGEND:**

- Monitoring Well Cluster Locations
- Soil Boring Locations (Note: Shallow soil locations not shown due to scale limitations)
- ▲ Surface Water Sampling Locations
- △ Shallow Soil Sample Locations
- ⇐ Inferred Groundwater Flow Directions
- ↖ Axis and Slope Directions of Bedrock Ridge

**FIGURE 1**  
**STUDY SITES AND SAMPLING LOCATIONS**

Table 1  
Well Construction and Sample Analysis Summary

Sample Number	Depth (Feet)	Screen Length (Feet)	Soil		Sample Type	Groundwater	Surface Water
			Number of Samples Collected	Number of Samples Analyzed		Number of Samples Analyzed	Number of Samples Analyzed
BG1B	77.0	15	32		W	1	
BG1S	50.0	15	11		W	1	
MW1B	148.3	15	26		W	1	
MW1S	20.5	10	5		W	1	
MW2B	146.0	15	60	1	W	1	
MW2S	32.5	10	7	1	W	1	
MW3B	85.5	15	14		W	1	
MW3S	58.5	10	11		W	1	
MW4B	81.4	15	16		W	1	
MW4S	14.0	10	3		W	Dry	
MW5B	91.5	15	16		W	1	
MW5S	27.0	10	6	1	W	1	
MW6B	84.5	15	47		W	1	
MW6S	16.0	10	4		W	1	
MW7B	54.0	10	22		W	1	
MW7S	16.5	10	4		W	1	
MW8B	36.0	10	6		W	1	
MW8S	17.3	10	4		W	1	
MW9B	40.0	10	7		W	1	
MW9S	16.0	10	4		W	1	
MW10B	88.0	15	16		W	1	
MW10S	17.5	10	4		W	1	
MW11B	110.5	15	21		W	1	
MW11S	20.0	10	4		W	1	
B-1	20.0		10	3	B		
B-2	20.0		10	3	B		
B-3	20.0		10	3	B		
B-4	20.0		10	3	B		
B-5	20.0		10	3	B		
B-6	10.0		5	1	B		
B-7	16.0		8	2	B		
SS-1	2.0			1	HA		
SS-2	3.0			1	HA		
SS-3	2.5			1	HA		
SS-4	3.0			1	HA		
SW-1	Surface				SW		1
SW-2	Surface				SW		1
SW-3	Surface				SW		1
SW-4	Surface				SW		1
Total			413	25		23	4

W = Monitoring Well  
B = Boring  
HA = Hand Augering  
SW = Surface Water



collected with a split spoon sampler. Three shallow soil samples were collected by hand auger at Site 1 in order to evaluate the contamination potential on the steep slope of the ash disposal fill area. All samples were examined and described in the field.

## 2.2 GROUNDWATER

Twenty three groundwater samples (Table 1) were collected from a perimeter monitoring well network consisting of 12 well clusters containing two wells each. At each location, one well is screened at the water table and the other is in the upper zone of fractured bedrock. These wells were constructed in order to determine whether and the extent to which potential constituents may have migrated from near the surface to deeper levels. All of the deeper wells were cored at least 10 feet into bedrock. After all of the wells were installed and developed, the locations and elevations of the monitoring wells were surveyed. Water levels were measured on June 16, 1989 and the first round of water quality samples was collected by bailer from June 21 to 27, 1989. Additional rounds of groundwater sampling remain to be conducted at this time. However, this memorandum contains only data from the first round in its assessments.

## 2.3 SURFACE WATER

Four water samples were collected at storm sewer outfalls and analyzed to evaluate potential constituent contributions to surface water quality from stormwater runoff.

# 3.0 SITE CONDITIONS

## 3.1 GEOLOGY

Previously available information (Haley & Aldrich, 1987)<sup>1</sup> suggests that Hartwell Hill consists of a bedrock knob covered by 40 feet or less of unconsolidated glacial till. The findings of this investigation, however, indicate that the thickness of

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<sup>1</sup>Haley & Aldrich, 1987, Hanscom Air Force Base (Hanscom AFB) Remedial Investigation Interpretive Report.



the glacial sediments and the orientation and surface shape of bedrock are much different than was originally described.

### 3.1.1 Fill Materials

Fill material consisting mostly of brown subrounded sand and gravel covers major portions of NWIRP Bedford. Fill material in the northern portion of the site also includes black ash, wood, copper metal wire, cement blocks, and additional debris at monitoring wells MW3B and MW3S and at borings B-3 and B-4. Generally, fill materials average 10 feet on Hartwell Hill. However, up to twenty-three feet of fill was encountered in the northern portion of the site at monitoring well MW3B, adjacent to the ash disposal area. The fill thins out to trace amounts in the southern region at monitoring wells MW8B and MW9B.

### 3.1.2 Unconsolidated Sediments

The northwestern portions of NWIRP Bedford are underlain by layers of glacial till, up to 128 feet thick at monitoring well MW1B. These are dense, tight, mostly olive gray sands with alternating subangular gravels, silts and clays. Random two foot thick lenses of brown, well-sorted, coarse sand are found within the glacial till. The glacial till decreases in thickness to the south, pinching to 17 feet at monitoring well MW7B and disappearing at monitoring wells MW8B and MW9B. Brown, well sorted sand and gravel glacio-fluvial outwash deposits ranging from 19 feet at monitoring well MW8B to 24 feet at monitoring well MW7B replace and overlay the glacial till sediments.

A 7 foot thick light-gray, silty sand layer at monitoring wells MW8B and MW9B divide the glacio-fluvial outwash deposits in the southern portion of the site. This sequence may be correlated with light gray silts and clays of the lacustrine deposit that were identified to the south by Haley & Aldrich in their 1987 report. The sequence is absent to the north on Hartwell Hill at the other monitoring wells.

### 3.1.3 Bedrock

Bedrock consists of gray granodiorite, black gabbro diorite, and gneiss. Its depth ranges from 26 feet at monitoring well MW8B in the southern portion of the site to 136 feet at monitoring well MW1B in the northwestern portion of the site.

The bedrock surface forms a broad ridge trending northeast to southwest. This feature parallels and is roughly centered on Hartwell Road at NWIRP Bedford. The ridge slopes to the northwest and southeast under the site with the majority of NWIRP Bedford northwest of Hartwell Road overlaying the northwesterly slope of the bedrock ridge and the remainder overlaying the southwestern slope of its axis (Figure 1).

Bedrock elevation is highest, 115 feet above mean sea level (msl), at monitoring well MW6B. It is above 100 feet msl at monitoring wells MW7B, MW8B, MW9B, and MW4B. The bedrock surface slopes sharply downward to the northwest in the northwestern portion of the site to 36 feet msl at monitoring wells MW1B and MW2B. Bedrock elevations are presented in Appendix A.

### 3.2 GROUNDWATER

Groundwater is supplied largely by precipitation that infiltrates at the land surface. Infiltrated water moves downward through unsaturated soils until it reaches the water table. Both glacial materials and bedrock beneath the water table are saturated. Glacial till, outwash sands and bedrock are in direct hydraulic contact with each other. As a result, groundwater can move between them downward or laterally toward areas where it is discharged, such as streams, wetlands, or wells.

Water level data used to evaluate the configuration of the regional water table and groundwater flow directions were taken from three sources: measurements from wells constructed during this study, reports (primarily related to Hanscom AFB and the Hartwell Road Wellfield), and topographic map elevations of Elm Brook. The water table near Bedford NWIRP is typically 15 to 30 feet below the surface, and roughly follows the surface topography. Groundwater tends to move at right angles to the slope of the water table. The highest observed water table elevation, 185 feet MSL, occurs in well MW6S near the peak of Hartwell's Hill. The water table slopes radially from this location, steeply to the north, south, and east and less steeply to the west. In lower areas to the south and east of the site, the water table is very flat joining an elevation of 120 feet msl in the area of Hanscom Field. Groundwater elevations are shown in Appendix A.



Groundwater also has a considerable downward head gradient within the till. Water elevations in the bedrock wells are typically 10 to 25 feet lower than in wells near the water table. This large vertical gradient may be accounted for by the low vertical hydraulic conductivity of the till. At well sites MW8 and MW9, where materials above bedrock are glacial outwash sands, water levels in deep and shallow wells are essentially identical. Little vertical gradient exists in this area because the high hydraulic conductivity of these materials allows rapid equilibration of water levels.

As indicated above, groundwater flows radially downward from the area around MW6 on Hartwell Hill (Figure 1). Groundwater at Site 1 and Site 2 appears to be flowing downward to the northwest, probably discharging to Elm Brook. At the western portion of the site in the vicinity of monitoring well clusters MW10 and MW11, groundwater flows to the west. At monitoring well clusters MW7, MW8, and MW9 located at the southern portion of the site, groundwater flows to the south towards Hanscom AFB. At the eastern portion of the site in the vicinity of monitoring well cluster MW6 groundwater flows to the east towards Hartwell Road.

## **4.0 DATA ANALYSIS**

### **4.1 SAMPLE ANALYSIS**

Samples collected during this investigation were submitted to CompuChem Laboratories Inc. for analysis. Samples were analyzed in accordance with appropriate EPA methodologies as identified in the Work Plan. However, during soil sample analysis, CompuChem Laboratories Inc. experienced equipment difficulties which necessitated analysis of PAH constituents using EPA Method 625 for PP VOC instead of EPA method SW-846 as originally planned (PAH is a subset of the PP VOC analyses). Laboratory analysis results are summarized on tables provided in Appendix A. The following summarizes the analyses performed:

- o Soil samples from the three borings at Site 1 were submitted for analysis of PP Total Metals and PP BNA. The surface soil samples collected from the same site by hand auger were analyzed for PP Total Metals.



- o Soil samples collected from the borings in Site 2 were analyzed for PP VOC and TPH. Samples collected from B-7 were also analyzed for PP BNA.
- o The three soil samples collected from bore holes during monitoring well construction (sample MW-S-1 from MW2B at 22.5 to 23 feet deep, MW-S-2 from MW5S at 4.5 to 5 feet deep, and MW-S-3 from MW2S at 20 to 21 feet deep) as a result of positive jar headspace test detections were analyzed for PP Total Metals, PP VOC, and TPH. Sample MW-S-3 was also analyzed for PP BNA.
- o All 23 shallow and deep groundwater samples were analyzed for PP VOC and PP Total Metals. Shallow groundwater samples were also analyzed for TPH. Select shallow and deep groundwater samples were analyzed for iron (Fe), manganese (Mn), and sulfates.
- o The four surface water samples were analyzed for PP Total Metals and TPH.

#### 4.2 ANALYTICAL RESULTS

All evaluations related to groundwater quality and potential constituent impacts in this report are based on a single round of water samples. Consequently, findings must be considered preliminary and are subject to change after evaluation of the remaining three rounds of data have been completed.

Where applicable, evaluation criteria were used to determine the seriousness of contamination. Criteria used to evaluate chemical data are identified in the Work Plan and include EPA and Massachusetts MCLs and health advisories (HA), EPA Ambient Water Quality Criteria (AWQC), and ranges of elements found in natural soils (as determined in the USGS Professional Paper 1270)<sup>2</sup>. Where criteria do not exist, detection of a compound above its detection limit is identified. Applicable, relevant, and appropriate requirements will be developed as the project progresses. The following sections summarize the results of data analysis.

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<sup>2</sup>H.T. Shacklette and J.G. Boerngen, Element Concentration in Soils and Other Surficial Materials of the Conterminous United States, USGS Professional Paper 1270, p. 6, 1984.

#### 4.2.1 Soil Samples

##### 4.2.1.1 Site 1

For most soil boring and surface soil samples, metal constituents were well within normal ranges found in soils of the eastern U.S. Silver was detected in four samples (i.e., B1-1, B1-3, B2-1, and B2-3). This information indicates that potential PP metals are not elevated to levels of concern.

PP BNA compounds were detected in two surface soil boring samples, B1-1, and B3-1. Fluoranthene and Pyrene were detected in both samples at levels ranging from 440 to 720 ug/kg and 410 to 920 ug/kg, respectively. Sample B3-1 contained the highest levels of BNA compounds (i.e., total BNA compounds = 7,970 ug/kg). The most elevated compounds in sample B3-1 were benzo(a)pyrene (1,100 ug/kg), benzo(k)fluoranthene (1,200 ug/kg), chrysene (1,100 ug/kg), and pyrene (920 ug/kg). Trace levels of several other PP BNA compounds were detected in these two samples as well as samples B2-1 and B3-3. No criteria are available for evaluating organic constituents detected in soil samples.

##### 4.2.1.2 Site 2

PP VOC compounds were only detected in one soil boring sample. Chloroform was detected at a level of 6 ug/kg in sample B5-3. (Methylene chloride was detected above the detection limit in most soil including laboratory sample blanks and is likely a laboratory contaminant.)

One PP BNA compound, Bis(2-Ethylhexyl)phthalate, was detected in samples B7-1 and the duplicate of B7-2 at levels of 710 and 770 ug/kg, respectively, and was also detected at trace levels in sample B7-2.

TPH constituents were detected in all the soil boring samples at levels ranging from 35 to 620 mg/kg. The highest TPH levels were detected in samples B6-1 (collected at the surface from B-6), B5-2 (collected at 12 feet from B-5), and B4-1 (collected at 2 feet from B-4).



#### 4.2.1.3 Other Areas

Soil samples collected in other areas of the site include the three soil samples collected from monitoring well boreholes. Laboratory results for these samples are summarized below:

- o Metal constituents were well within the normal range of metals found in soils of the eastern U.S.
- o PP VOC compounds were not detected.
- o No PP BNA compounds were detected in sample MW-S-3.
- o TPH constituents were detected in two of the soil samples, MW-S-2 (MW5S) and MW-S-3 (MW2S), at 340 and 33 mg/kg, respectively.

#### 4.2.2 Groundwater

##### 4.2.2.1 Shallow

PP VOCs were detected in five of the eleven shallow groundwater samples collected (i.e., MW1S, MW2S, MW5S, MW8S, and MW11S). Trichloroethylene and 1,2-dichloroethylene were the most prevalent compounds detected and ranged from 10 to 850 ug/l and 23 to 160 ug/l, respectively. Other compounds detected include 1,1-dichloroethane (BDL to 160 ug/l), 1,2-dichloroethane (17 to 19 ug/l), 1,1-dichloroethylene (17 to 680 ug/l), methylene chloride (BDL to 21 ug/l), tetrachloroethylene (BDL to 130 ug/l), and 1,1,1-trichloroethane (BDL to 450 ug/l). The highest levels of PP VOCs were detected in MW-11S. Trace levels of trichloroethylene were also detected in sample BG1S. EPA/MA MCLs or HAs were only available for these compounds, as follows: 1,2-dichloroethane, 5 ug/l; 1,1-dichloroethylene, 7 ug/l; methylene chloride, 150 ug/l; tetrachloroethylene, 5 ug/l (proposed); 1,1,1-trichloroethane, 200 ug/l; trichloroethylene, 5 ug/l; and 1,2-dichloroethylene 70 ug/l (proposed for each isomer, Cis and Trans). (Criteria are not available for the remaining PP VOCs detected in groundwater.)

TPH constituents were detected in three of the eleven shallow groundwater samples collected (i.e., MW-1S, MW-9S and MW-10S) at levels slightly exceeding analytical detection limits (from 1 to 2.5 mg/l). (Criteria do not exist for evaluating TPH constituents detected in groundwater.)



Most PP Metal constituents were not elevated above the EPA/MA MCL/HA criteria in either the filtered or unfiltered shallow groundwater samples. For filtered samples, antimony was detected in only one sample (i.e., MW-11S) at a level of 40.6 ug/l. (There are no criteria available for evaluating antimony in groundwater.) For unfiltered samples, antimony was also detected in the MW-1S duplicate sample at 41.1 ug/l. Also for unfiltered groundwater samples, chromium was elevated above the EPA/MA MCLs in two groundwater samples (i.e., MW-1S and MW-9S) at levels ranging from 123 to 558 ug/l, arsenic was elevated in one sample (MW-9S) at a level of 234 ug/l, and lead was elevated in one sample (MW-1S) at a level of 188 ug/l. (The EPA/MA MCLs for chromium, arsenic, and lead are all 50 ug/l.

Ten filtered shallow and deep groundwater samples were submitted for analysis of iron, manganese and sulfates. Iron exceeded the secondary EPA MCL (300 ug/l) in only one sample. Sample BG1S contained 366 ug/l of iron. Manganese was elevated above the secondary EPA MCL (50 ug/l) in eight of the groundwater samples. Manganese levels ranged from 98.0 to 782 ug/l. Sulfates were not elevated above the secondary EPA MCL (250 ug/l) in any of the groundwater samples.

#### 4.2.2.2 Deep

PP VOCs were detected in two of the twelve deeper groundwater samples collected (i.e., MW-5B and MW-8B). Trichloroethylene and 1,2-dichloroethylene (total) were detected in both of these wells at levels of 42 to 230 ug/l and 10 to 78 ug/l, respectively. EPA MCLs for these compounds are 5 ug/l for trichloroethylene and 70 ug/l (proposed) for each of the 1,2-dichloroethylene isomer (Cis and Trans). No other PP VOCs were detected in the deeper wells.

Most PP Metal constituents were not elevated above the EPA/MA MCL/HA criteria in either the filtered or unfiltered deep groundwater samples. Chromium was detected in the duplicate of one unfiltered groundwater sample (i.e., MW-3B) at a level of 53.8 ug/l, which is elevated above the EPA/MA MCL (i.e., 50 ug/l). No other metal constituents were elevated.

#### 4.2.3 Surface Water Runoff

Copper, lead and zinc were detected above the AWQC criteria in three of the surface water samples (SW-2, SW-3, and SW-4). Copper was detected at levels ranging from 31.1 to 212 ug/l in these samples, lead was detected at levels ranging from 7.7 to 33.4 ug/l, and zinc was detected at levels ranging from 154 to 211 ug/l. (The AWQC for copper, lead and zinc are 12, 3.2 and 110 ug/l, respectively.) Arsenic was detected in two surface water samples (i.e., SW-2 and SW-4) at levels of 52 and 5.1 ug/l, respectively. (An AWQC is not available for evaluating arsenic in surface water.)

No PP VOC compounds were detected in the surface water samples.

TPH was detected at low concentrations in two surface water samples (i.e., SW-3 and SW-4) at 1 and 1.1 mg/l, respectively. These concentrations are very close to the analytical detection limits. (Criteria are not available for evaluating TPH constituents in surface water.) However, NPDES discharge limits for TPH are 10 mg/l.

#### 4.3 CONTAMINATION ASSESSMENT

##### 4.3.1 Site 1, Old Incinerator Ash Disposal Area

The major potential constituents of concern at Site 1 as expressed by the Initial Assessment Study<sup>3</sup> were related to metals which may have been generated from incinerator ash and paint waste disposal. Chemical analyses performed on soil samples indicate the presence of silver, which is not typically found in soils. Silver was only detected in samples collected from Site 1 borings which indicates that the incinerator ash deposits are the likely source. Lead and other paint related metals were below concentrations normally found in soils. Consequently, incinerated paint wastes are not likely to be major contributors to metal constituents.

Groundwater flow from Site 1 is towards wells MW1, MW2 and MW3. Chemical analyses performed on samples from these wells indicate that dissolved

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<sup>3</sup>Rogers, Golden and Halpern, Initial Assessment Study Naval Weapons Industrial Reserve Plant, Bedford, Massachusetts, Naval Energy and Environmental Support Activity 13-099, April 1986.



heavy metal constituents are not being mobilized from the site at levels of concern since no metals were detected above MCLs in filtered groundwater samples. Chromium and lead (above MCLs in well MW1S) and silver (below MCLs in wells MW1 and MW3) were detected in unfiltered groundwater samples. However, the presence of these constituents are attributed to minor amounts of suspended sediment due to their absence in the filtered samples.

Soil and groundwater samples at Site 1 were also analyzed for organic constituents. PP BNA compounds were detected primarily in the shallowest soil boring samples. This seems to indicate that they originated from the overlying asphalt pavement through which the borings were constructed.

Chlorinated organic compounds (TCE and 1,2 Dichloroethylene) were detected in shallow groundwater (wells MW1 and MW2) and TPH was detected in MW1. The chlorinated organic constituents are commonly associated with paint solvents, thinners and degreasing agents. Three septic fields are located in the immediate vicinity of these two wells and may be major potential sources. Automotive shop operations are situated very close to MW1 and may have contributed constituents to the wells. Groundwater flows toward the wells from two old UST locations and from Site 2. Leaks from USTs and constituents in groundwater at these locations may have also contributed to MW1 and MW2.

#### 4.3.2 Site 2, Components Laboratory Fuel Oil Tank

Two borings were originally planned and installed in this area to investigate potential impacts from a leaking UST, located on the northeast corner of the Components Laboratory. Two additional borings were installed during field activities. This expanded the area of investigation when it became apparent that the disturbed area around a downgradient buried pipeline had intercepted a portion of the migrating material. In addition, a soil sample collected from MW5S which is situated to the northeast, was submitted for analysis.

Site 2 is located very close to the groundwater divide. As a result, groundwater flows in several directions from the area, toward the northwest, east, southeast and southwest. TPH analyses performed on soil samples indicate that the higher concentrations of constituents in surface soils are southeast of the UST



location. In deeper soil and groundwater samples, the concentrations are greatest northeast of the UST location. The original discharge which raised concern about the site is to the northwest. The sample collected from outfall SW4 which receives runoff from areas east of the Components Laboratory also contains slightly elevated TPH concentrations.

The distribution of these locations indicates that petroleum related materials have migrated extensively in the soils of this area and that the greatest concentrations were identified to the southeast. The most likely source is the UST of concern, however, two other possible sources located in the site may have also contributed constituents. These include an old UST location situated east of the AMRAD Building and surface runoff that flows northeast from the Components Laboratory and AMRAD Building. Though numerous potential groundwater flowpath directions exist, no evidence indicates that migration is occurring. Consequently, it appears to be a soil problem at this site.

Elevated concentrations of PP VOCs were also identified at the site which are related to chlorinated organic solvents. The greatest concentrations are in groundwater samples (shallow and deep at MW5) located east of the Components Laboratory. The most likely potential source is disposal from the paint shop. This is located in the eastern side of the Laboratory at a location upgradient from where the solvents were detected.

#### 4.3.3 Other Source Areas

Constituents were detected in three other well locations that cannot be directly linked with sources at Sites 1 or 2. These include the following:

- o Flight Test Facility and Hanger: PP VOCs related to chlorinated organic solvents were detected in shallow and deep groundwater samples collected from MW8, TPH was detected in MW9S, and arsenic and chromium were elevated above the MCLs in unfiltered groundwater collected from MW9S. Potential sources at this location include the Fire Training Area to the northeast and aircraft maintenance activities, a number of current and old UST locations, and a hazardous materials and waste storage facility to the north.

Groundwater in this area flows toward the south and wells MW8 and MW9 are situated along the NWIRP Bedford's southern perimeter.

The outfall at sample location SW1 receives stormwater runoff from most locations upgradient from MW9. No constituents were detected in SW1. The stormwater outfall for areas directly upgradient of MW8 discharge from the outfall at sample location SW3. SW3 contained TPH and levels of copper, lead, and zinc that were above the AWQC. The significance and segregation of a specific potential surface source is difficult to determine due to the limited data.

- o Photocopy and Print Shop: Well MW11 is situated south of the print shop. The greatest concentrations of PP VOCs related to chlorinated organic solvents identified at NWIRP Bedford were detected in the shallow groundwater sample collected from this well. Runoff or waste disposal from print shop activities and/or flow from Site 2 are possible sources of the constituents. Groundwater flows from east to west through this area.
- o Components Laboratory: The most elevated concentrations of TPH were detected in MW10S. This site is situated west-southwest of the Components Laboratory in close proximity to and downslope from the large asphalt parking lot. It is most likely that these constituents originate from infiltrating parking lot runoff.

Unfiltered surface water samples collected at outfall sampling points SW2 and SW4 contain concentrations of arsenic, copper, lead, and zinc which were elevated above AWQC. These outfalls receive drainage from areas east and south of the Components Laboratory. It is probable that suspended sediments transported to the site account for the elevated constituents.

#### 4.3.4 Occurrence of Iron, Manganese and Sulfate

Five monitoring well locations were sampled and analyzed for dissolved iron, manganese, and sulfates (wells BG-1S, BG-1B, MW-1S, MW-1B, MW-2S, MW-2B, MW-3S, and MW-11B). Iron was elevated above the secondary MCL in one well



(BG1), manganese was elevated above the secondary MCL in all wells sampled, and sulfates were below the secondary MCL in all samples. Concentrations were comparatively greater in the shallower wells.

Elevated concentrations of manganese and iron are common in the glacial soils of northeastern U.S. and are generally present in groundwater. The range of iron detected at NWIRP Bedford (64.3 to 366 ug/l) is within reported natural concentrations (100 to 50,000 ug/l)<sup>4</sup> and is considerably less than comparable values at the Hartwell Road Wellfield (720 to 4700 ug/l)<sup>5</sup>. Manganese and sulphate concentrations at the two locations are generally equivalent. Manganese is usually present at levels less than 200 ug/l; at NWIRP Bedford detections are 98.9 to 782 ug/l and at the Hartwell Road Wellfield they are 570 to 610 ug/l. Sulfate concentrations at NWIRP Bedford are 19 to 42 mg/l and at the Hartwell Road Wellfield they are 35 to 48 mg/l.

## 5.0 RISK ASSESSMENT

The methodology of this preliminary Risk Assessment generally follows guidance provided by EPA, in particular, the Superfund Public Health Evaluation Manual<sup>6</sup> and the Superfund Exposure Assessment Manual<sup>7</sup>. The risk evaluation is based on only one round of environmental sampling and should be considered preliminary.

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<sup>4</sup>C.A. Lindberg and J.E. Ayres, Volume I - Geohydrologic Study Systems Laboratory Raytheon Bedford, Goldberg-Zoino & Associates, File No. A-7761.21, December 1988.

<sup>5</sup>T.F. Cheyer, Report on Pumping Test at Well No. 29 Near Hartwell Road, Camp Dresser & McKee, Inc., January 2, 1981.

<sup>6</sup>U.S. Environmental Protection Agency (USEPA), Superfund Public Health Evaluation Manual, EPA 540/1-86/060, Office of Emergency and Remedial Response, Washington, D.C., 1986a.

<sup>7</sup>U.S. Environmental Protection Agency (USEPA), Superfund Exposure Assessment Manual, EPA/540/1-88/001, Office of Remedial Response, Washington D.C., April, 1988.



## 5.1 CONSTITUENTS OF CONCERN

The principal constituents of concern at NWIRP Bedford are the chlorinated organic solvents detected in groundwater throughout the installation, specifically: trichloroethene, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene. These chlorinated solvents were detected in five shallow monitoring wells and two deep monitoring wells at concentrations that are not acceptable based upon their exceedances of EPA/MA MCLs.

Other constituents detected at elevated levels include PP BNA compounds in soil at Site 1, petroleum hydrocarbons in soil at Site 2, chromium and arsenic in groundwater from MW9S, and chromium and lead in groundwater from MW1S. These compounds are not considered a concern because of generally low toxicity (Public Health Risk Evaluation Database, 1988) and lack of potential human exposure (petroleum hydrocarbons); adequate containment (PP BNAs); and lack of mobility (metals in unfiltered samples that were not detected in corresponding filtered samples).

## 5.2 POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

The potential receptors to constituents detected at NWIRP Bedford consist of personnel on or offsite who may come in contact with the above listed contaminants of concern.

The primary potential exposure pathway to hazardous constituents detected at NWIRP Bedford is ingestion of contaminated groundwater, either by onsite personnel or by offsite personnel. Currently, this exposure pathway is not complete as no drinking water wells are known to exist onsite. However, offsite receptors exist that may potentially consume contaminated groundwater originating from NWIRP Bedford. These potential receptors include people residing approximately one-half mile to the northwest of NWIRP Bedford on Hartwell Road. Nonhuman environmental receptors are not likely to be impacted by the constituents detected at NWIRP Bedford.

### 5.3 PUBLIC HEALTH EVALUATION

Although no receptors are known to currently exist that are exposed to constituents at NWIRP Bedford, the possibility exists that in the future wells could be installed in contaminated groundwater or that the extent of contamination could impact existing drinking water offsite wells. To assess this potential public health risk a conservative, preliminary calculation of exposure and the resulting risk was performed. Using the concentrations of chlorinated solvents detected in the monitoring wells, a simple exposure scenario of an adult drinking 2 ltr/day of groundwater over a 70 year exposure time, and EPA published health effects criteria (Integrated Risk Information System)<sup>8</sup>, a maximum carcinogenic risk was estimated for exposure to groundwater from MW11S of  $1.2 \times 10^{-2}$  (see sample calculation below). This carcinogenic risk is in excess of the acceptable range of  $10^{-4}$  to  $10^{-6}$  prescribed by EPA.

Sample calculation (based on a single analysis of groundwater from MW11S):

$$\text{contaminant intake (mg/kg/day)} = \frac{[\text{groundwater contaminant concentration (mg/l)} \times \text{groundwater ingestion (ltr/day)}]}{\text{adult body weight (kg)}}$$

$$\text{intake of 1,1-dichloroethene} = \frac{0.68 \times 2}{70} = 1.94 \times 10^{-2}$$

(Same calculation for other potential carcinogens.)

$$\text{risk} = [\text{intake} \times \text{potency factor (mg/kg/day)}^{-1}]$$

$$\text{risk from 1,1-dichloroethene} = 1.94 \times 10^{-2} \times 0.6 = 1.17 \times 10^{-2}$$

(Total risk is sum of risks posed by exposure to all potential carcinogens.)

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<sup>8</sup>U.S. Environmental Protection Agency (USEPA), Integrated Risk Information System (IRIS), 1989a.



## 6.0 CONCLUSIONS

The bedrock surface under Hartwell Hill forms a buried ridge trending northeast to southwest, sloping sharply downward to the northwest. It is overlain by till, up to 128 feet thick. Outwash sediments, 17 feet thick, occur to the south.

A single aquifer exists at the site in which groundwater has a downward head gradient. Flow is radial from a central location in the vicinity of the Components Laboratory. The water table gradient is steeply inclined to the north, south, and east and is gentler to the west.

The distribution of constituents include the following:

### 6.1 SOLVENTS

#### 6.1.1 Distribution

- o Solvent related detections in soil at sampling points were very minor.
- o In groundwater, 1,2 dichloroethene and 1,1,1 trichloroethene were detected at widely distributed locations. Perimeter well detections occur in the north, south, east, and west.
- o Concentrations appear to be greatest in shallow groundwater. The most heavily contaminated well is MW11 (e.g., TCE 850 ppb). Wells MW1, MW2, and MW11 contain solvents in only the shallow groundwater. Wells MW5 and MW8 contain solvents in both shallow and deep groundwater indicating that at these points contamination may be more widespread. The remaining wells contain no solvents.
- o Solvents were not found in surface water runoff.
- o The concentration of chlorinated solvents in groundwater at the site poses a potential health risk.

#### 6.1.2 Source Relationships

- o The near absence of solvents in soil together with their presence in groundwater indicates that sources were upgradient and could only be inferred from the downgradient location of contaminated groundwater.



- o Groundwater detections appear to be part of a solvent mixture which may have originated from multiple sources due to their distributions and variable constituent combinations present at well sites. However, the long groundwater flowpaths extending radially from MW6 towards Site 1, Site 2, MW 11, or MW8 make it impossible to determine if potential sources are close, distant, or mixtures.
- o Detections in Site 1 are in the vicinity of abandoned septic fields and the automotive shop, but, they are also downgradient of Site 2.
- o The southern plume associated with MW8 is in close proximity to the Hanscom AFB Fire Training Area which has documented TCE detections of 48,000 ppb. However, other potential sources also exist which could be associated with activities to the north.
- o The western area associated with MW11 is close to the print shop, however, it is also downgradient from Site 2.
- o MW5 is also downgradient of Site 2 and could be associated with the paint shop or other activities in the Components Laboratory.
- o The extent of migration beyond NWIRP Bedford could not be determined since groundwater sampling points downgradient from wells containing constituents are unavailable.

## 6.2 PETROLEUM RELATED

- o Groundwater TPH concentrations, where noted, were in very low concentrations at or near detection limits.
- o Though present at other locations, the petroleum related constituents were noted primarily in soils at Site 2. TPH concentrations were elevated in both shallow and deep soils at this site, however, they were not noted in associated groundwater. This indicates that migration, if it has occurred, is limited.
- o TPH concentrations in groundwater were also slightly elevated (2.5 mg/l) at well MW10S which probably originated from infiltrating parking lot runoff.

### 6.3 PP METALS

- o PP metal constituents are not a problem. Soil and groundwater concentrations (unfiltered) in Site 1 are generally low and constitute no health risk due to their isolation from human exposure.
- o Metals concentrations exceeded AWQC at three outfalls for copper, lead and zinc.

## 7.0 RECOMMENDATIONS

Based on evaluation of the first round of sampling, (i.e., over and above the continuation of three more sampling rounds) Dames & Moore is of the opinion that additional sampling and site assessment is required. Dames & Moore's recommendations are as follows:

### 7.1 SITE ASSESSMENT AND RECORDS REVIEW

Due to the detection of chlorinated hydrocarbons in several groundwater samples, additional assessment of the site should be conducted in order identify potential sources. This assessment should include the following:

- o Conduct a site assessment of all potential contributors of chlorinated hydrocarbons, including paint shops, print shops, automotive shops (or other maintenance shops using degreasers) and laboratories.
- o Review engineering drawings for septic fields to determine if potential source areas drained into any of the septic fields.

### 7.2 CHANGES TO SAMPLING PLAN, ROUNDS 2 THROUGH 4

- o Dames & Moore recommends that either PP VOC (EPA Method 624) or purgeable halocarbons/hydrocarbons (EPA Methods 602/601) be conducted on all groundwater samples (deep and shallow). EPA Method 624 is used to screen the constituents present. After the suite of constituents has been identified, a determination should be made to insure that all constituents are included in the EPA Method 601/602



analyses. If they are, the latter methods should be conducted to refine the concentrations since these tests have lower detection limits.

- o Surface water samples need only be analyzed for metal constituents during the remaining rounds since other tested constituents were not noted.

### 7.3 ADDITIONS TO SAMPLING PLAN

Additional soil borings, monitoring wells, and a soil-gas survey are recommended at various locations on the site in order to better delineate the extent of constituents, to isolate sources, and to identify migration characteristics (Figure 2). Unless otherwise specified, additional sampling should be conducted following the same protocols used for the initial sampling. The following is recommended:

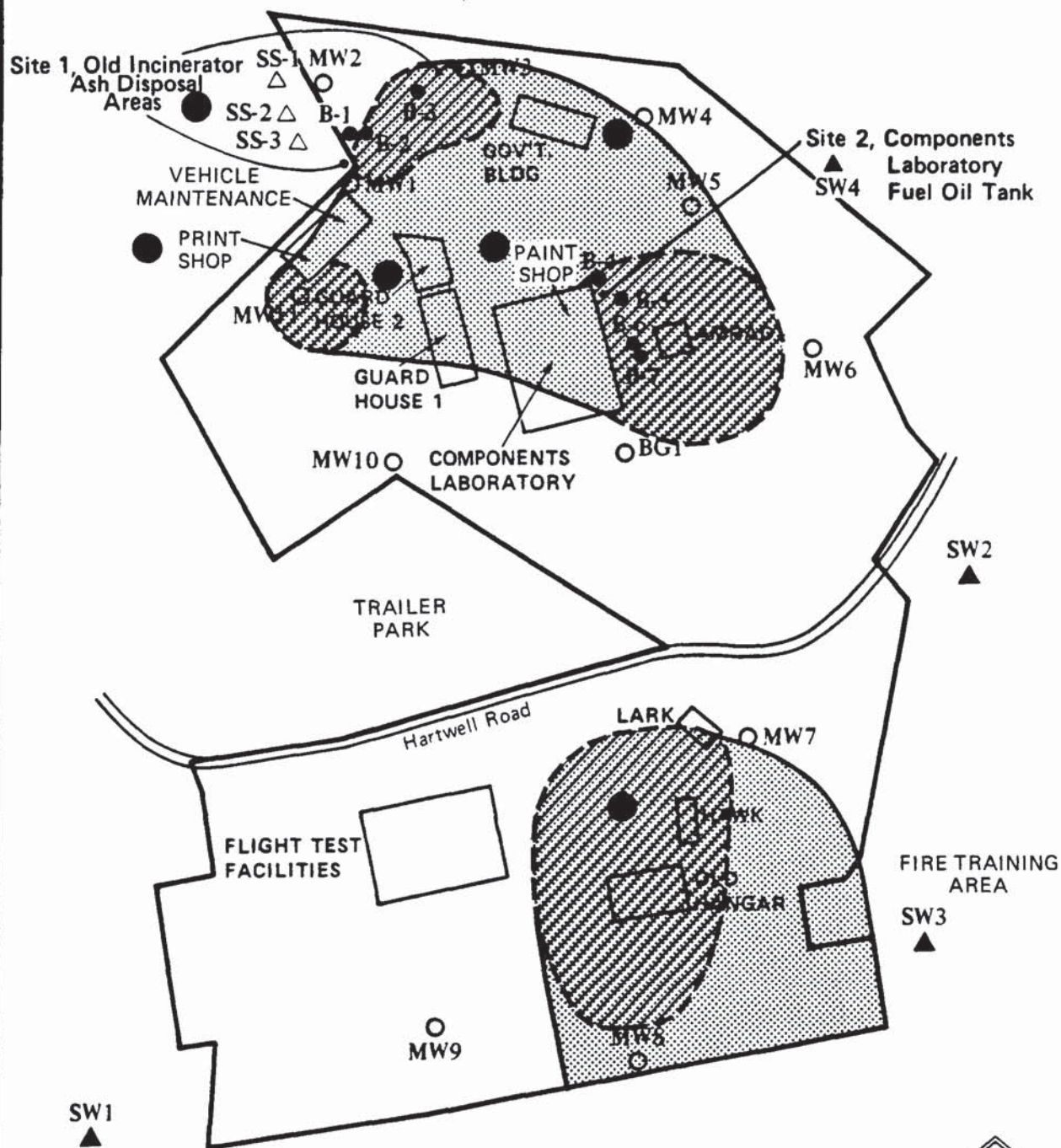
#### 7.3.1 Soil-Gas Survey

A active soil-gas investigation is proposed to preliminarily screen the distribution of solvent constituents at NWIRP, Bedford. The results would be used to assist in locating additional soil borings and monitoring wells.

The survey would be conducted in two locations (Figure 2). Soil gas-samples would be extracted from the subsurface and analyzed in the field at the time of sample collection (in contrast to a passive method which requires later analysis). The samples would be collected using a 100 foot grid with the grid being adjusted in the field as data is acquired, plotted, and evaluated in order to define the contamination extent.

#### 7.3.2 Soil Samples

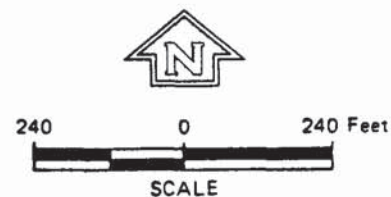
- o Additional soil borings are recommended at Site 2 in order to evaluate the extent of fuel constituents. Soil samples should be analyzed for PP VOC.



**LEGEND:**

- Monitoring Well Cluster Locations
- Soil Boring Locations (Note: Shallow soil locations not shown due to scale limitations)
- ▲ Surface Water Sampling Locations
- △ Shallow Soil Sample Locations

- Proposed Boring Locations
- Proposed Monitoring Well Locations
- Proposed Soil-Gas Sampling Locations



**FIGURE 2**  
**PROPOSED SAMPLING LOCATIONS**



- o Based on the information gathered during the site assessment, additional borings may also be required in areas of the NWIRP Bedford site in order to assess the extent and source location of chlorinated hydrocarbons. This may include the following four areas: the septic fields and automotive shop around Site 1, the paint shop at Site 2, the photocopy and print shop near MW11, and the area near the Flight Test Facility and Hanger. For each site requiring soil sampling, Dames & Moore recommends the samples be analyzed for PP VOC.
- o The exact location of the sampling points would be based on evaluations of the soil-gas survey and findings from other data sources.

### 7.3.3 Monitoring Wells

- o Three sets of shallow and deep groundwater monitoring wells are recommended at the following approximate locations: 120 feet north of the Components Laboratory aligned between MW6 and MW1; 160 feet west of the Components Laboratory aligned between MW5 and MW11; and 100 feet west of the HAWK Building upgradient of MW8 (or as an alternative, 150 feet northeast of MW8 towards the fire training area if this appears to be the source of the constituents identified). The exact location of the sampling points would be based on evaluations of the soil-gas survey and findings from other data sources. These sites occupy intermediate positions between potential solvent sources that lay along the same groundwater flowpaths. Data from them would enable the identification and differentiation of potential solvent contributor areas at well locations where detections have occurred.
- o A shallow monitoring well should be installed to replace well MW4 which is dry. This is recommended to provide a sample which can be evaluated for petroleum and solvent migration. When MW4S was drilled, water was encountered at approximately 10 feet. It was subsequently determined after installing the well that this water was

perched, of limited volume and did not recharge after purging. According to data from other shallow monitoring wells in the vicinity, groundwater will probably be encountered at approximately 35 feet from the surface. Therefore, the well should be reconstructed to intercept the actual water column. Well MW4 should be properly abandoned.

- o Two sets of shallow and deep groundwater monitoring wells are recommended at locations approximately 300 feet downgradient of MW2 and MW11. This is recommended to evaluate the extent of migration to offsite locations. It is recognized that these wells would not be on Navy owned property and that special access approvals would be required.

#### 7.4 ASSESSMENT OF SURROUNDING SITES

In order to evaluate the impact of the NWIRP Bedford site on surrounding properties, Dames & Moore recommends that a thorough assessment be performed of all data and evaluations that were conducted on surrounding properties, including Raytheon, Hascom AFB, and Hartwell Road Well Field. Additionally, in order to evaluate groundwater conditions and movement, simultaneous groundwater level measurements should be taken for all wells located within 1 mile of the NWIRP Bedford site, including those sites discussed above.



## APPENDIX A

Table A-1  
Surface, Bedrock, and Groundwater Elevations  
NWIRP, Bedford, MA

WELL Number	SURFACE Elevation (Feet msl)	BEDROCK Elevation (Feet msl)	CW Elev. 7/09/89 (Feet msl)	CW Elev. 10/10/89 (Feet msl)
BC1B	199.2	131.7	158.12	155.53
BC1S	199.2		169.24	174.31
MW1B	172.2	36.2	123.31	147.92
MW1S	172.0		160.97	160.60
MW2B	168.9	35.9	118.75	117.30
MW2S	168.9		146.49	146.44
MW3B	171.5	96.0	120.37	119.17
MW3S	171.5		136.44	135.40
MW4B	176.0	103.0	121.93	121.47
MW4S	175.8		DRY	DRY
MW5B	186.0	104.5	151.34	155.01
MW5S	184.9		166.55	165.36
MW6B	189.4	115.4	135.19	133.06
MW6S	189.6		184.78	181.01
MW7B	153.7	109.7	130.21	129.45
MW7S	153.7		142.02	139.68
MW8B	132.1	106.1	122.56	121.87
MW8S	132.0		122.23	121.48
MW9B	131.9	101.9	123.00	122.11
MW9S	132.7		122.70	121.94
MW10B	162.0	85.0	145.40	142.90
MW10S	161.8		154.07	152.68
MW11B	166.5	66.0	124.62	125.21
MW11S	166.8		153.25	154.20



**APPENDIX B**

Table B-1  
Analytical Results for PP Metals, PP BNA, Percent Solids, and Percent Moisture  
in Soil Boring Samples Collected at Site 1, NWIRP, Bedford, MA

	SAMPLE ID SAMPLING DEPTH	B1-1 0	B1-2 6	B1-3 16	B2-1 4	B2-2 10	B2-3 15	B3-1 0	B3-2 2	B3-3 4	Detection Limits for PP BNA	Occurrence of Metals In Eastern U.S. Soils Mean Range	
PP Metal (mg/kg)													
Arsenic		5.3 [ ]	4.7	4	5.6 [ ]	5.5	4.7	7.7	9.5	7.8		7.4	<0.1-73
Beryllium		0.48 [ ]	0.5 [ ]	0.51 [ ]	0.5 [ ]	0.55	0.51 [ ]	0.48 [ ]	0.5 [ ]	0.51 [ ]		0.85	<1 - 7
Chromium		21	22.5	29.6	20.9	18.8	13.2	17.7	14.6	12.7		52	1 - 1,000
Copper		26.7	15.3	23	17	16.5	17	13.1	10	9.8		22	<1 - 700
Lead		27	7.7	4.5	7.6	6	4.2	14.2	7.2	22.1		17	<10 - 300
Nickel		13	14.2	28.8	13.3	13	11.1	12.7	8.6	6.5		18	<5 - 700
Silver		3.1	0.55 U	0.66 [ ]	7.7	0.53 U	16.5	0.53 U	0.54 U	0.55 U		-	-
Zinc		117	40.3	54.1	98.3	37.9	45	30.4	26.8	19.3		52	<5 - 2,900
PP BNA (ug/kg)													
Acenaphthylene		BDL	BDL	BDL	BDL	BDL	BDL	260 J	BDL	41 J		370	
Anthracene		BDL	BDL	BDL	BDL	BDL	BDL	73 J	BDL	BDL		370	
Benzo(a)anthracene		240 J	BDL	BDL	56 J	BDL	BDL	740	BDL	97 J		370	
Benzo(a)pyrene		89 J	BDL	BDL	BDL	BDL	BDL	1100	BDL	110 J		370	
Benzo(b)fluoranthene		270 J	BDL	BDL	BDL	BDL	BDL	690	BDL	220 B		370	
Benzo(g,h,i)perylene		170 J	BDL	BDL	BDL	BDL	BDL	460	BDL	82 J		370	
Benzo(k)fluoranthene		210 J	BDL	BDL	BDL	BDL	BDL	1200	BDL	220 J		370	
bis(2-Ethylhexyl)phthalat		41 J	BDL	BDL	41 J	BDL	BDL	51 J	BDL	BDL		370	
Chrysene		290 J	BDL	BDL	75 J	BDL	BDL	1100	BDL	150 J		370	
Dibenzo(a,h)anthracene		BDL	BDL	BDL	BDL	BDL	BDL	190 J	BDL	BDL		370	
1,2-Dichlorobenzene		BDL	BDL	BDL	BDL	BDL	BDL	210 J	BDL	60 J		370	
Fluoranthene		440	BDL	BDL	78 J	BDL	BDL	720	BDL	100 J		370	
Fluorene		BDL	BDL	BDL	BDL	BDL	BDL	99 J	BDL	BDL		370	
Indeno(1,2,3-cd)pyrene		140 J	BDL	BDL	BDL	BDL	BDL	450	BDL	74 J		370	
Phenanthrene		240 J	BDL	BDL	45 J	BDL	BDL	590	BDL	78 J		370	
Pyrene		410	BDL	BDL	82 J	BDL	BDL	920	BDL	150 J		370	
4-Nitrophenol		300 J	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL		370	
4-Chloro-3-methylphenol		41 J	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL		370	
Percent Solids		90.4	89	90.2	88.6	91.6	88.8	91.2	90.6	89.4			
Percent Moisture, Undecanted		10	11	10	11	8	11	9	9	11			

PP - Priority Pollutant, BNA - Base/Neutral/Acid Extractibles

BDL - Below Detection Limit

mg/kg - milligrams per kilogram

ug/kg - micrograms per kilogram

Sample Qualifiers:

[ ] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL).

B - Analyte was detected in laboratory blank.

J - Estimated concentration of analyte which is present but at a concentration less than the stated detection limit.

U - Analyzed for but not detected, reported value is detection limit.



Table B-2  
Analytical Results for PP Metals and Percent Solids  
in Surface Soil Samples Collected from Site 1, NWIRP, Bedford, MA

	SAMPLE CON	SS-1 268413	SS-2 268421	SS-3 268422	SS-4 268423	Occurrence of Metals in Eastern U.S. Soils	
	SAMPLING DEPTH	0	0	0	0	Mean	Range
PP Metals (mg/kg)							
Arsenic		5.6	4.7	5.5	4.6	7.4	<0.1 - 73
Beryllium		0.11 U	0.10 U	0.11 U	0.10 U	0.85	<1 - 7
Chromium		12.9	8.9	10	8.5	52	1 - 1,000
Copper		13.2	9.1	12.9	9.2	22	<1 - 700
Lead		4.2	3.6	5.9	2.9	17	<10 - 300
Nickel		5.4 []	5.3 []	4.1 U	3.9 U	18	<5 - 700
Zinc		18.3	18.7	23.5	15.4	52	<5 - 2,900
Percent Solids							
		89.4	93.6	89.6	93.6		

CON - CompuChem Sample ID

PP - Priority Pollutant

mg/kg - milligrams per kilogram

Sample Qualifiers

[] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL).

U - Analyzed for but not detected, reported value is detection limit.

Table B-3  
Analytical Results for PP VOC, PP BNA, TPH, and Percent Moisture  
in Soil Boring Samples Collected at Site 2, NWIRP, Bedford, MA

SAMPLE ID SAMPLING DEPTH	B4-1 2	B4-2 10	B4-3 18	B5-1 8	B5-2 12	B5-3 17	B6-1 0	B7-1 8	B7-2 14	B7-2 Dup 14	Detection Limit
PP VOC (ug/kg)											
Chloroform	2 J B	2 J	1 J	1 J	2 J	6	2 J	1 J	BDL	1 J	6
Methylene chloride	19 B	20 B	83 B	29 B	22 B	16 B	36 B	23 B	21 B	20 B	11
1,2-Dichloroethene(Total)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	2 J	BDL	6
PP BNA (ug/kg)											
Bis(2-Ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	710	310 J	770	380
TPH (mg/kg)	77	39	35	52	450	56	620	39	39	NA	25
Percent Moisture, Undecanted	9	9	9	9	11	10	10	10	10	11	

PP VOC - Priority Pollutant Volatile Organic Compounds

PP BNA - Priority Pollutant Base/Neutral/Acid Extractible Compounds

TPH - Total Petroleum Hydrocarbons

ug/kg - micrograms per kilogram

mg/kg - milligrams per kilogram

BDL - Below Detection Limit

Sample Qualifiers

B - Analyte was detected in laboratory blank.

J - Estimated concentration of analyte which is present but at a concentration less than the stated detection limit.

NA - Sample not submitted for chemical analysis.



Table B-4  
Analytical Results for PP Metals, PP VOC, TPH, Percent Solid and Percent Moisture  
in Soil Samples Collected from Monitoring Well Borings, NWIRP, Bedford, MA

SAMPLE ID	MW-S-1	MW-S-2	MW-S-3	Detection	Occurrence of Metals	
MONITORING WELL	MW-2B	MW-5S	MW-2S	Limit for	In Eastern U.S. Soils	
SAMPLING DEPTH	21.5-23	4.5-5	20-21	Organics	Mean	Range
PP Metals (mg/kg)						
Antimony	7.0 U	6.9 U	4.9 [ ]		0.76	<1 - 8.8
Arsenic	3.8 [ ]	5.4	18.4		7.4	<0.1 - 73
Beryllium	0.32 [ ]	0.51 [ ]	0.7		0.85	<1 - 7
Chromium	8	19.9	29.8		52	1 - 1,000
Copper	8.2	10.9	23.7		22	<1 - 700
Lead	4.5	9.8	7.2		17	<10 - 300
Nickel	5.8 [ ]	11.2	17.1		18	<5 - 700
Zinc	14.9	37.3	57		52	<5 - 2,900
PP VOC (ug/kg)						
Chloroform	1 J	BDL	2 J B	6		
Methylene chloride	4 J B	14 B	18 B	11		
PP BNA (ug/kg)						
	NA	NA	ND			
TPH (mg/kg)						
	BDL	340	33	1		
Percent Solids						
	90	90.8	90			
Percent Moisture, Undecanted						
	12	9	8			

PP - Priority Pollutant

VOC - Volatile Organic Compound

BNA - Base/Neutral/Acid Extractible Compounds

TPH - Total Petroleum Hydrocarbon

mg/kg - milligrams per kilogram

ug/kg - micrograms per kilograms

Sample Qualifiers:

[ ] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL).

B - Analyte was detected in laboratory blank.

J - Estimated concentration of analyte which is present but at a concentration less than the stated detection limit.

U - Analyzed for but not detected, reported value is detection limit.

NA - Sample not submitted for analysis.

ND - Sample submitted for analysis, but no analytes were detected.

Table B-5  
Analytical Results for PP VOC, TPH and pH  
in Groundwater Samples, NWIRP, Bedford, MA

SAMPLE ID	BG-1S	BG-1B	NW-1S	NW-1B	NW-2S	NW-2B	NW-3S	NW-3B	NW-4B
PP VOC (ug/l)									
1,1-Dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
methylene chloride	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	BDL	BDL	6 J	BDL	17	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethylene	9 J	BDL	10	BDL	100	BDL	BDL	BDL	BDL
1,2-Dichloroethylene(Total)	BDL	BDL	DL	BDL	160	BDL	BDL	BDL	BDL
TPH (mg/l)	BDL	NA	1	NA	BDL	NA	BDL	NA	NA
pH	7.17	7.53	5.75	7.90	6.05	7.94	8.64	7.80	7.64
Conductivity (umhos)	296	254	396	428	939	460	307	310	450

SAMPLE ID	NW-5S	NW-5S Dup	NW-5B	NW-6S	NW-6B	NW-7S	NW-7B	NW-8S	NW-8B
PP VOC (ug/l)									
1,1-Dichloroethane	8 J	9 J	6 J	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	17	19	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethylene	17	24	BDL	BDL	BDL	BDL	BDL	BDL	BDL
methylene chloride	BDL	7 J	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethylene	6 J	6 J	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethylene	75	81	42	BDL	BDL	BDL	BDL	11	230
1,2-Dichloroethylene(Total)	23	24	78	BDL	BDL	BDL	BDL	BDL	10
TPH (mg/l)	BDL	NA	NA	BDL	NA	BDL	NA	BDL	NA
pH	5.58	5.58	7.46	5.81	8.64	5.75	7.28	6.20	6.98
Conductivity (umhos)	726	726	594	760	425	141	176	214	745

SAMPLE ID	NW-9S	NW-9B	NW-10S	NW-10B	NW-11S	NW-11B	Detection Limit	EPA/MA MCL/HA
PP VOC (ug/l)								
1,1-Dichloroethane	BDL	BDL	BDL	BDL	160	BDL	10	-
1,2-Dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	10	5
1,1-Dichloroethylene	BDL	BDL	BDL	BDL	680	BDL	10	7
methylene chloride	BDL	BDL	BDL	BDL	21	BDL	10	150
Tetrachloroethylene	BDL	BDL	BDL	BDL	130	BDL	10	5 *
1,1,1-Trichloroethane	BDL	BDL	BDL	BDL	450	BDL	10	200
1,1,2-Trichloroethane	BDL	BDL	BDL	BDL	8 J	BDL	10	-
Trichloroethylene	BDL	BDL	BDL	BDL	850	BDL	10	5
1,2-Dichloroethylene(Total)	BDL	BDL	BDL	BDL	36	BDL	10	70 **
TPH (mg/l)	1	NA	2.5	NA	BDL	NA	1	-
pH	5.95	6.74	5.67	8.07	6.04	7.09		6.5-8.5
Conductivity (umhos)	221	790	293	354	842	550		

PP VOC - Priority Pollutant Volatile Organic Compounds  
TPH - Total Petroleum Hydrocarbons  
ug/l - micrograms per liter  
mg/l - milligrams per liter  
BDL - Below Detection Limit

EPA/MA MCL/HA - EPA and Massachusetts maximum contamination level or health advisory

\* - Proposed MCL

\*\* - Proposed MCL. The proposed MCLs for Cis- and Trans-1,2-dichloroethylene are 70 and 100 ug/l, respectively.

A conservative assumption was made that the detected value consisted solely of the Cis isomer

Sample Qualifiers

J - Estimated concentration of analyte which is present but at a concentration less than the stated detection limit.



Table B-6  
Analytical Results for PP Metals, Iron, Manganese, and Sulfates  
in Filtered Groundwater Samples, NWIRP, Bedford, MA

SAMPLE ID CON	BG-1S 269769	BG-1B 270177	MW-1S 270029	MW-1S Dup 270032	MW-1B 270036	MW-2S 269770	MW-2S Dup 269976	MW-2B 270183	MW-3S 270178	MW-3B 269308
PP Metal (ug/l)										
Antimony	U	U	U	U	U	U	U	U	U	U
Arsenic	6.9 [ ]	16.4	1.3 [ ]	U	2.4 [ ]	1.7 [ ]	U	3.6 [ ]	5.7 [ ]	10.2
Beryllium	U	U	U	U	U	U	U	U	U	1.3 [ ]
Chromium	9.1 [ ]	U	U	6.7 [ ]	7.3 [ ]	8.7 [ ]	9.1 [ ]	5 [ ]	4.2 [ ]	U
Copper	U	10.1 [ ]	U	U	U	U	U	U	10 [ ]	U
Lead	3.4 [ ]	7.3	2.5 [ ]	1.4 [ ]	2 [ ]	10.4	9.9	2.1 [ ]	U	U
Mercury	U	U	U	U	U	U	U	U	U	U
Nickel	U	U	U	21.2 [ ]	U	19.6 [ ]	U	U	U	U
Silver	U	U	U	U	U	U	8.5 [ ]	U	U	U
Zinc	42.9	19.3 [ ]	12.9 [ ]	4 [ ]	6.4 [ ]	23.3	16 [ ]	13.4 [ ]	14.6 [ ]	4.1 [ ]
Iron (ug/l)	366	69.3 [ ]	170	NA	64.3 [ ]	83.2 [ ]	NA	225	U	NA
Manganese (ug/l)	782	581	136	NA	98.9	582	NA	269	185	NA
Sulfates (mg/l)	30	23	19	NA	28	28	NA	27	20	21

SAMPLE ID CON	MW-3B Dup 269315	MW-5S 270025	MW-6S 269199	MW-7S 269316	MW-8S 270235	MW-9S 269320	MW-10S 270236	MW-11S 270449	MW-11B 270445	Detection Limit	EPA/MA MCL/HA
PP Metal (ug/l)											
Antimony	U	U	U	U	U	U	U	40.6 [ ]	U	31.5	-
Arsenic	10.5	2 [ ]	1.2 [ ]	4.5 [ ]	U	5.1 [ ]	U	U	1.8 [ ]	1.2	50
Beryllium	1.9 [ ]	U	U	3.9 [ ]	U	1.3 [ ]	U	U	U	0.5	1,750
Chromium	U	8.3 [ ]	4.8 [ ]	U	U	U	U	U	U	3.8	50
Copper	U	U	14.9 [ ]	U	10 [ ]	U	U	10 [ ]	9.4 [ ]	7.3	1,000
Lead	U	10.2	1.8 [ ]	U	U	U	U	U	1.5 [ ]	0.9	50
Mercury	U	U	0.24	U	U	U	U	U	U	0.2	2
Nickel	19.8 [ ]	21.8 [ ]	U	U	U	U	U	U	U	18.6	700
Silver	U	U	U	U	U	U	U	U	U	4.9	50
Zinc	3.4 [ ]	15.9 [ ]	12.3 [ ]	93.4	22.6	14.8 [ ]	22.4	25.2	U	1.2	5,000
Iron (ug/l)	NA	NA	NA	NA	NA	NA	NA	NA	154	3.2	300
Manganese (ug/l)	NA	NA	NA	NA	NA	NA	NA	NA	399	NR	50
Sulfates (mg/l)	NA	NA	NA	NA	NA	NA	NA	18	42	1	250

CON - CompuChem Sample ID

PP - Priority Pollutant

ug/l - micrograms per liter

mg/l - milligrams per liter

NA - Sample not submitted for chemical analysis.

NR - Detection limit not reported by laboratory

EPA/MA MCL/HA - EPA and Massachusetts maximum contamination level or health advisory.

Sample Qualifiers:

[ ] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL)

U - Analyzed for but not detected, see detection limit

Table B-7  
Analytical Results for PP Metals, Iron, Manganese, and Sulfates  
in Unfiltered Groundwater Samples, NWIRP, Bedford, MA

SAMPLE ID CON	BC-1S 270180	MW-1S 270030	MW-1S Dup 270033	MW-1B 270037	MW-2S 270174	MW-2S Dup 270175	MW-2B 270176	MW-3S 270179	MW-3B 269304	MW-3B Dup 269310
PP Metals (ug/l)										
Antimony	U	U	41.4 [ ]	U	U	U	U	U	U	U
Arsenic	5.9 [ ]	4.5 [ ]	4.8 [ ]	1.5 [ ]	5.1 [ ]	4.6 [ ]	3.8 [ ]	5 [ ]	11.5	10.4
Beryllium	3.1 [ ]	3.2 [ ]	16.6	U	3.7 [ ]	3.1 [ ]	3.2 [ ]	0.61 [ ]	2.6 [ ]	3.8 [ ]
Chromium	19.3	146	558	8.7 [ ]	45.2	28.7	U	12.6	25.2	53.8
Copper	U	74.5	318	U	25.1	10.1 [ ]	U	U	U	U
Lead	35.5	30.7	188	1.8 [ ]	39.1	37.4	2 [ ]	12.4	26.1	42.5
Nickel	U	99.8	367	U	42.9	37.5 [ ]	U	U	19.7 [ ]	40.4
Selenium	U	U	U	U	U	U	U	U	U	U
Silver	U	5 [ ]	U	5.4 [ ]	U	U	U	5.2 [ ]	U	U
Zinc	123	214	770	5.3 [ ]	156	89.3	23.7	114	77.3	102

SAMPLE ID CON	MW-5S 270026	MW-6S 269205	MW-7S 269317	MW-8S 270237	MW-9S 269319	MW-10S 270241	MW-11S 270448	Detection Limit	EPA/MA MCL/HA
PP Metals (ug/l)									
Antimony	U	U	U	U	U	U	U	31.5	-
Arsenic	3.5 [ ]	1.6 [ ]	1.8 [ ]	18.8	234	U	2.1 [ ]	1.2	50
Beryllium	3.6 [ ]	U	3.8 [ ]	1.1	7.4	U	U	0.50	1,750
Chromium	49.1	11.1	5.6 [ ]	29.4	123	U	7.8 [ ]	3.8	50
Copper	14.9 [ ]	U	U	19.9	91	U	U	7.3	1,000
Lead	30.6	4.2 [ ]	4.4 [ ]	14.7	48.6	1.4	33.6	0.9	50
Nickel	59.7	U	U	20.8	85.3	U	U	0.2	700
Selenium	U	U	9.5 [ ]	U	7.7 [ ]	U	U	18.6	10
Silver	6.4 [ ]	U	U	U	U	U	U	4.9	50
Zinc	64.4	38	81.8	83.7	192	17.5	313	1.2	5,000

CON - CompuChem Sample ID

PP - Priority Pollutant

ug/l - micrograms per liter

NA - Sample not submitted for chemical analysis.

NR - Detection limit not reported by laboratory

EPA/MA MCL/HA - EPA and Massachusetts maximum contamination level or health advisory.

Sample Qualifiers:

[ ] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL).

U - Analyzed for but not detected, see detection limit.



Table B-8  
Analytical Results for PP Metal and TPH  
in Surface Water Samples, NWIRP, Bedford, MA

SAMPLE ID	SW-1	SW-2	SW-3	SW-4	Detection Limit	EPA AWQC (FCC)
PP Metals (ug/l)						
Arsenic	BDL	52	BDL	5.1 []	1.2	-
Beryllium	BDL	BDL	2.6 []	BDL	0.5	5.3
Chromium (Total)	BDL	12.6	4 []	13	3.8	210 *
Copper	BDL	212	31.1	92.1	7.3	12
Lead	0.99 []	33.4	20.5	7.7	0.9	3.2
Selenium	6.4 []	BDL	1.3 []	BDL	1	35
Zinc	44	154	207	211	NR	110
PP VOC (ug/l)	ND	ND	ND	ND		
TPH (mg/l)	BDL	BDL	1	1.1	1	

PP - Priority Pollutant

VOC - Volatile Organic Compounds

TPH - Total Petroleum Hydrocarbons

BDL - Below Detection Limit

EPA AWQC (FCC) - EPA Aquatic Water Quality Criteria (Fresh Water Chronic Criteria)

Sample Qualifiers:

[] - Analyte was detected above the instrument detection limit (IDL) but below the contract required detection limit (CRDL).

U - Analyzed for but not detected, see detection limit

NR - Detection limit not reported by laboratory

ND - Samples submitted for analysis, but analytes were not detected

\* - Assumes trivalent chromium

Table B-9  
Analytical Results of Methylene Chloride  
for Field, Sample, and Trip Blanks  
at NWIRP, Bedford, Massachusetts

Field Blanks

Sample ID	Sample Source	Methylene Chloride (ug/l)
F-1	Distilled Water	BDL
F-2	Water Truck	BDL
F-3	Water Hose	BDL
F-4	Distilled Water	BDL
F-5	Water Hose	BDL
F-6	Water Truck	BDL
F-7	Distilled Water	BDL
F-8	Water Hose	BDL
F-9	Water Truck	BDL
F-10	Distilled Water	BDL
F-11	Water Hose	BDL
F-12	Water Truck	BDL
F-15	Distilled Water	21
F-16	Distilled Water	BDL

Sample Blanks

Sample ID	Sample Source	Methylene Chloride (ug/l)
R-2	Rinsate	BDL
R-3	Rinsate	BDL
R-5	Rinsate	BDL
R-6	Rinsate	11
R-8	Rinsate	BDL
R-10	Rinsate	BDL
R-12	Rinsate	BDL
R-16	Rinsate	BDL
R-17	Rinsate	BDL
R-18	Rinsate	BDL
R-19	Rinsate	BDL

Trip Blanks

Sample ID	Sample Source	Methylene Chloride (ug/l)
TB-1	Lab Water	BDL
TB-2	Lab Water	BDL
TB-3	Lab Water	5J

ug/l - micrograms per liter

BDL - Below Detection Limits

J - Estimated concentration of analyte which is present but at a concentration less than the detection limit.